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Interventional Radiology Role in Conservative Management of Placenta Accreta Spectrum: A Narrative Review

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Abstract Placenta accreta spectrum (PAS) is a significant obstetric complication characterized by abnormal placental attachment and invasion into the myometrium, leading to severe risks during delivery, including substantial hemorrhage. This systematic review the evolving role of interventional radiology (IR) in the conservative management of PAS. It highlights various IR techniques, including pelvic arterial embolization, pre-operative arterial access with intra-operative embolization, and balloon occlusion methods. Those innovative techniques can effectively control hemorrhage, reduce the need for hysterectomy, and preserve fertility in appropriately selected PAS patients. The review underscores the importance of a multidisciplinary approach and individualized management strategies to optimize patient outcomes in this challenging obstetric condition.

Key Words Placenta accreta spectrum, Interventional radiology, Pelvic arterial embolization, Conservative management, Postpartum hemorrhage

INTRODUCTION

Placenta accreta spectrum (PAS) constitutes a significant obstetric challenge characterized by abnormal trophoblastic invasion into the myometrium. This pathological condition occurs when placental trophoblastic cells abnormally adhere to or invade the myometrial layer, resulting in failure of normal placental separation during the third stage of labor [1]. The International Federation of Gynecology and Obstetrics (FIGO) has established a standardized grading system for PAS: Grade 1 (adherent placenta), Grade 2 (invasive placenta with intact serosa), and Grade 3 (invasive placenta with serosa invasion). Grade 3 is further stratified based on involvement of surrounding structures: serosal involvement (3a), bladder invasion (3b), and invasion of other pelvic tissues or organs (3c) [2].

The incidence of PAS has demonstrated a significant upward trend in recent decades, with reported rates reaching 0.26% in Saudi Arabia and 0.31% in the United States [3,4]. This increase correlates directly with the rising prevalence of cesarean deliveries globally. The risk escalates exponentially with each subsequent cesarean section, from 0.2% after the first cesarean delivery to 2.3% after the fifth [4]. In the presence of placenta previa, these risks increase dramatically-from 3% after the first cesarean to approximately 67% after the fifth procedure [4].

Diagnostic evaluation typically commences with antenatal ultrasound screening for suspected cases as ultrasound carries an overall sensitivity of 81.2%-93.0% and specificity of 94.7-98.9% [5], with magnetic resonance imaging (MRI) providing complementary diagnostic information and facilitating surgical planning with overall sensitivity of 86.5% -100% and specificity of 96.8%-98.8% [6]. However, definitive diagnosis is established only at delivery. Risk factors for PAS extend beyond cesarean history to include advanced maternal age, assisted reproductive technologies, multiparity, prior placental disorders, and previous uterine surgical interventions [2,3,4].

Traditionally, cesarean hysterectomy has been considered the standard therapeutic approach for PAS, involving complete removal of both the placenta and uterus [7]. However, this approach precludes future fertility and carries significant perioperative morbidity. Consequently, conservative management strategies have emerged as viable alternatives for appropriately selected candidates, aiming to preserve uterine integrity while effectively managing the condition [7].

Interventional radiology (IR) has emerged as a crucial component in the multidisciplinary management of PAS, offering various techniques to control hemorrhage, the most

life-threatening complication of this condition. These procedures aim to occlude arterial blood flow to the uteroplacental complex using minimally invasive approaches. IR techniques encompass emergency arterial embolization for postpartum hemorrhage and prophylactic measures such as pre-delivery catheter placement, balloon occlusion of iliac arteries, or abdominal aortic balloon occlusion [8-25].

This systematic review examines the evolving role of IR in the conservative management of placenta accreta spectrum, analyzing the efficacy, safety profiles, and clinical outcomes of various endovascular approaches in optimizing surgical management and improving patient outcomes for this challenging obstetric condition.

Pelvic Arterial Embolization for post-partum hemorrhage

Pelvic arterial embolization has been utilized for several decades in the management of postpartum hemorrhage, with applications now extending to PAS cases. This technique aims to achieve multiple therapeutic objectives: controlling distal bleeding sources, minimizing surgical morbidity, inducing thrombosis of intervillous spaces, promoting placental resorption, and preserving fertility potential. A comprehensive understanding of the pelvic angiographic anatomy in PAS patients is essential, as it frequently differs from typical cases of postpartum hemorrhage. Patients with prior pelvic surgeries may have undergone arterial surgical ligation, leading to recruitment of extra-uterine arteries to supply the uteroplacental complex. Beyond the uterine arteries, blood supply may be derived from ovarian, pudendal, obturator, sacral, and inferior epigastric arteries. In advanced PAS cases, arterial blood supply may also be recruited from invaded organs such as the bladder or colon, rendering these structures vulnerable to ischemic complications during embolization procedures. The selection of embolic agents is depending upon the clinical scenario and desired duration of occlusion: Temporary Agents: Gelatin sponge or slurry (Gelfoam) represents the most widely utilized temporary occlusive agent, providing short-term hemostasis while allowing for eventual recanalization of the vessel. Permanent Agents: For cases requiring more durable occlusion, options include: N-butyl-2-cyanoacrylate (medical adhesive) combined with oil-based contrast medium, Metallic coils for larger vessel occlusion, Polyvinyl alcohol particles for intermediate-term occlusion and Calibrated microspheres for precise and predictable occlusion.

Standard pelvic arterial embolization used as an alternative in patient with post-partum hemorrhage when uterotonic agents and conventional obstetric interventions failed to control bleeding if the patient remains hemodynamically stable (systolic blood pressure >90 mmHg). In hemodynamically unstable patients, surgical hysterectomy is typically indicated. The embolization procedure is performed in the interventional radiology suite via unilateral femoral arterial access. Pelvic angiography is obtained using diagnostic catheters with or without microcatheter systems. Embolization is performed to achieve blood flow stasis in at least one uterine artery (with additional pelvic branches embolized as necessary). Multiple prospective and retrospective studies have evaluated the efficacy of pelvic arterial embolization for postpartum hemorrhage in patients undergoing conservative management for PAS: Hwang and colleagues conducted a comprehensive retrospective analysis of 40 PAS patients who underwent pelvic arterial embolization. Utilizing primarily Gelfoam with or without particles (supplemented with liquid embolic agents in five patients and coils in six patients), they achieved 100% technical success. The initial clinical success rate was 82.5%, improving to 92.5% after re-embolization in three patients. Only three patients (7.5%) ultimately required hysterectomy after failed embolization. Procedure-related complications were minor (7.5%), including transient pelvic pain, nausea, and urticaria, with no major complications reported [8]. In a comparative study by Soyer et al. [10], they did a retrospective analysis of 12 PAS patients underwent pelvic arterial embolization with Gelfoam with or without particles. While technical success was achieved in all cases (100%), the initial clinical success rate was lower at 58%, improving to 83% after re-embolization in two patients. Two patients with placenta percreta and bladder involvement ultimately required hysterectomy despite embolization. All patients in this cohort experienced significant hemorrhage (>1000ml), with one access- related complication reported [9]. Li et al. reported a retrospective analysis of 10 PAS patients, achieving 100% technical and clinical success with Gelfoam embolization. No patients required re-embolization or hysterectomy. One patient developed ipsilateral deep vein thrombosis that was successfully managed with medical therapy, but no other major complications were observed [10]. Jung and colleagues evaluated 17 PAS patients retrospectively who underwent uterine artery embolization using Gelfoam in all cases, with additional particles in four patients and coils in two patients for more durable occlusion. They reported an 82.4% overall clinical success rate, with a mean estimated blood loss of 2062 ml. Three patients required hysterectomy after failed embolization. One patient developed transient postembolization syndrome, characterized by fever, pain, and leukocytosis, but no major complications were observed [11]. Wang et al. [12] performed a retrospective analysis of 18 PAS patients who underwent uterine artery embolization with Gelfoam, achieving a 94% overall clinical success rate and a mean estimated blood loss of 1328 ml. Only one patient required hysterectomy after failed embolization. Eight patients (44%) developed transient postembolization syndrome, a higher rate than in other studies, but no major complications were reported. A comprehensive systematic review and meta-analysis by Mei et al. examined 177 PAS patients who underwent pelvic arterial embolization across multiple studies. The overall clinical success rate was 89.8%, with 12 patients requiring

re-embolization and 20 patients (11.3%) ultimately undergoing hysterectomy after failed embolization. Notably, 87.1% of patients (74/85) for whom data was available resumed menstruation, indicating preservation of fertility potential. No maternal mortality was reported in this systematic review, supporting the safety profile of the procedure when performed by experienced operators [13].

Intra-Operative Pelvic Arterial Embolization After Fetal Delivery

Yu et al. [14] evaluated 11 PAS patients retrospectively who underwent bilateral uterine artery embolization with or without internal iliac artery embolization using Gelfoam following cesarean delivery. Following fetal delivery and umbilical cord clamping, intraoperative pelvic angiography is performed via the femoral sheath access using diagnostic catheters with or without microcatheter systems. Bilateral uterine artery embolization is performed until blood flow stasis is achieved. Subsequently, an attempt at placental removal is undertaken in most patients. They documented significantly lower estimated blood loss when the placenta was left in situ (760 mL in five patients) compared to when it was removed (2,075 mL in four patients). Two additional patients experienced massive hemorrhage (averaging 11,500 ml) requiring immediate hysterectomy despite embolization. One patient developed peritonitis at the surgical site requiring delayed hysterectomy three weeks postoperatively. Complete or near-complete placental resorption occurred within six to eight months in all patients who retained their uterus, demonstrating the potential efficacy of conservative management with embolization [14]. Huang and colleagues conducted a retrospective comparative study of 11 PAS patients who underwent bilateral uterine artery embolization with Gelfoam following cesarean delivery versus a control group. The embolization cohort demonstrated significantly lower estimated blood loss (990 mL vs. 3448 ml) and reduced transfusion requirements (2.9 units vs. 6.3 units). Only one of 11 patients (9.1%) in the embolization group required hysterectomy after a failed second embolization attempt, while three patients required intensive care unit admission for maternal complications or hemodynamic monitoring [15]. Bouvier et al. investigated 14 PAS patients retrospectively, with 12 undergoing bilateral uterine artery embolization using Gelfoam and calibrated/non-calibrated particles following cesarean delivery. The placenta was partially removed in six patients and left completely in situ in eight patients, allowing for comparison of these management approaches. Mean estimated blood loss was 1257 mL (range 200-3500 ml), with seven patients requiring blood transfusions (average 5.3 units). Two patients (16.7%) required emergency hysterectomy despite embolization due to severe postpartum hemorrhage (average estimated blood loss 3000 ml), and two additional patients underwent delayed hysterectomy due to complications including uterine necrosis, sepsis, and hematuria with bladder invasion [16].

Intra-Operative Pelvic Arterial Embolization Before Fetal Delivery

Giurazza et al [17]. conducted a large prospective multicenter study of 69 PAS patients who underwent bilateral uterine artery embolization using calibrated microparticles (500-700 μm), after which standard cesarean delivery completed. Thirty-six patients (52.2%) did not require blood product transfusion, and the mean estimated blood loss was 1200 mL (range 0-8000 ml). Hysterectomy was performed in 30 patients (43.5%) with deep placental invasion, massive hemorrhage, severe uterine atony, or organ compromise. The average fetal radiation dose was 26.75 mGy, with an average radiation exposure time of 195 seconds and iodine contrast dosage less than 20 mL.

Intra-Operative Pelvic Arterial Selection Before Fetal Delivery Followed by Embolization After Fetal Delivery

Pan et al [18]. evaluated 45 PAS patients retrospectively, with 26 undergoing contralateral uterine artery catheterization through a single ipsilateral femoral arterial access. Embolization with Gelfoam is then performed sequentially in the both uterine arteries until blood flow stasis is achieved. Following successful embolization, placental removal is attempted in most cases. Nine patients (34.6%) required more than six units of red blood cell transfusion, and eight (30.8%) underwent total or subtotal hysterectomy due to uncontrolled hemorrhage. The mean estimated blood loss was 2,080 mL overall, with significant differences observed between patients who underwent hysterectomy (4737 ml) and those who did not (900 ml). The average uterine/fetal radiation dose was 30.6 mGy. Adverse events included transient buttock pain in four patients and uterine necrosis in one patient, highlighting the potential complications associated with this approach. The average fetal absorbed radiation was 30.6 mGy (range 5.9-104 mGy) and exposure time was 158 seconds (range 41-524 seconds), respectively.

Bilateral Internal Iliac Balloon Occlusion

Angileri et al. [19] conducted a prospective study of 37 PAS patients (14 with placenta accreta, 3 with placenta increta, and 20 with placenta percreta) who underwent preoperative bilateral internal iliac artery balloon catheter placement through bilateral femoral arterial sheaths. Balloons inserted in the interventional radiology suite, which are tested, deflated, and secured to the skin. The patient is then transferred to the operating room. Following standard cesarean delivery with fetal delivery and umbilical cord clamping, the balloons are inflated to the pre-determined volume. Subsequently, placental removal is attempted in most patients. The balloons were inflated following delivery and maintained inflated for a minimum of four hours, with the option to re-inflate and consider embolization if hemorrhage recurred after deflation. Notably, no patients required hysterectomy. The mean (and the range) of estimated blood loss was 2052 mL overall (ranging between 400-4500 ml), with variations according to PAS subtype

(1649 mL (400-4000 ml) for accreta, 2933 mL (2000-3800 ml) for increta, and 2203 mL (1000-4500 ml) for percreta). Twenty-four patients (64.9%) required blood transfusions, and five (13.5%) developed postpartum hemorrhage, with four of these successfully managed with subsequent embolization. No peripheral or sheath-related arterial thrombosis was reported, suggesting a favorable safety profile for this technique. No detailed fetal radiation dose reported.

Bilateral Infra-renal Aortic Balloon Occlusion

Panici et al. [20] conducted a comparative prospective study of 33 PAS patient, 15 of them underwent preoperative infrarenal aortic occlusion balloon placement via bilateral 8 French femoral access (inflated upon fetal delivery) versus 18 control patients managed without placement of occlusion balloons. No details mentioned about the ability to level of the renal arteries. The balloon occlusion group demonstrated significantly lower rates of hysterectomy (13.3% vs. 50%), reduced estimated blood loss (950 mL (median range 790-1100) vs. 3375 mL (median range2645-4007 ml)), and decreased transfusion requirements (46.7% of patients with median 0 units vs. 100% of patients with median 4 units). The average occlusion duration was 32 minutes, with all cases maintained under 40 minutes to minimize ischemic complications. No endovascular-related complications were reported, suggesting that with appropriate technique and duration limitations, this approach can be safely implemented. The average fetal absorbed radiation was 0.1 mGy and exposure time was less than 5 seconds in all cases.

Unilateral Infra-renal Aortic Balloon Occlusion

Wei et al. [21] evaluated 45 PAS patients retrospectively (22 with placenta accreta, 20 with placenta increta, and 3 with placenta percreta) who underwent preoperative infra-renal aortic balloon placement via unilateral 5-8 French femoral access, with balloon inflation upon fetal delivery to the pre-determined volume. Placental removal is attempted in most patients. Once hemostasis is achieved, the balloon is deflated 5-10 minutes after the initial occlusion; if persistent hemorrhage is identified, the balloon is re-inflated for an equivalent duration until hemostasis is achieved. The mean estimated blood loss was 835 mL (range 200-6000 ml), with 11 patients (24.4%) requiring blood transfusions (mean 1.7 units). Four patients (8.9%) required subtotal hysterectomy due to excessive intraoperative hemorrhage despite balloon occlusion. Endovascular-related complications occurred in two patients (4.4%): one developed peripheral arterial thrombosis requiring embolectomy, and another experienced femoral nerve ischemic injury that was managed conservatively. The average fetal absorbed radiation was 4.1 (±2.3) mGy and exposure time was less than 5 (±1.9) seconds in all cases. Wu and colleagues conducted a larger retrospective comparative study of 268 PAS patients, with 230 receiving preoperative infra-renal aortic balloon placement via unilateral 8 French femoral arterial access and 38 serving as controls. T12 vertebral body used as an anatomical landmark for infra-renal aorta level. Balloon inflated upon fetal delivery to the pre-determined volume. The balloon occlusion cohort demonstrated estimated blood loss was 921 mL (±199 ml) in compare to 2790 mL (±335 ml) in the controlled group. Moreover, the blood transfusion requirements was 422±58 mL in the occlusion group while 1580±67 mL in the control group. No hysterectomies were required in the balloon occlusion group, compared to three (7.9%) in the control group. Only two patients (0.9%) in the balloon occlusion group required uterine artery embolization for active hemorrhage control. Complications were limited to two cases of peripheral venous thrombosis (0.9%) that were treated conservatively. No cases of arterial thrombosis, maternal mortality, or fetal mortality were reported. The average fetal absorbed radiation was 5.1 (±3.0) mGy. No specific fetal exposure time reported [22]. Luo et al. retrospectively evaluated 121 PAS patients who underwent preoperative infra-renal aortic balloon placement via unilateral 12 French femoral access, with 115 patients (95%) having balloon inflation upon fetal delivery. The mean estimated blood loss was 700 mL (range 400-1100 ml), with an average transfusion requirement of 150 mL (range 0-600). 20 patients (16.5%) required hysterectomy due to excessive hemorrhage during placental removal despite balloon occlusion. Endovascular-related complications included vascular thrombosis in 12 patients (11 patients had arterial thrombosis and 1 patient had deep vein thrombosis). 8 of these 12 thrombosis events were symptomatic and required thrombectomy, while others were managed conservatively. No fetal radiation exposure was recorded in this study [23].

Combined Balloon Occlusion and Embolization Techniques

Duan et al. [23] investigated 42 PAS patients retrospectively who underwent preoperative infra-renal aortic balloon placement via unilateral 8 French femoral access, balloon inflated upon fetal delivery to the pre-determined volume until hemostasis is accomplished. Following successful hemorrhage control and placental management, sequential embolization of the left and right uterine arteries with Gelfoam is performed until blood flow stasis is achieved. The mean estimated blood loss was 586±355 ml, with an average transfusion requirement 422±83 ml. Placental removal was attempted in all patients. However, invasive placental tissue necessitated in situ management in 35 cases (83.3%). One patient (2.4%) required hysterectomy due to uncontrolled hemorrhage despite balloon inflation and embolization. The average fetal absorbed radiation was 4.2±2.9 mGy and exposure time was 2.2 seconds (range 3-5 seconds). The mean occlusion time was 22.4±7.2 min. No maternal or fetal mortality or endovascular-related complications were reported [24]. D'Souza and colleagues evaluated 10 PAS patients retrospectively who underwent preoperative bilateral internal iliac balloon placement via bilateral 7 French femoral access, balloon inflated upon fetal delivery to the pre-determined volume until hemostasis is accomplished. Following cesarean delivery, all patients

underwent bilateral uterine artery embolization using Gelfoam. The mean estimated blood loss was 1200 mL (range 400-4000 mL), with only two patients (20%) requiring 2500 mL blood transfusions in each. The placenta was left in situ in six patients, partially removed in two, and completely removed in two patients. While no emergency hysterectomies were required during the initial procedure, four patients (40%) developed postpartum hemorrhage during follow-up, with three ultimately requiring delayed hysterectomy (on postoperative day 1, at week 9, and at week 11, respectively) [25].

CONCLUSIONS

Interventional radiology techniques represent valuable tools in the conservative management of placenta accreta spectrum, offering the potential to reduce morbidity and preserve fertility in selected cases. The optimal approach involves careful patient selection, multidisciplinary planning, and individualized management based on the specific clinical scenario and institutional capabilities. As research in this field continues to evolve, further refinement of techniques and clearer guidelines for patient selection will likely emerge, further improving outcomes for this challenging obstetric condition. Future research should focus on long-term outcomes, including fertility and subsequent pregnancy outcomes, as well as standardized protocols to guide the selection of specific interventional techniques based on PAS severity and patient characteristics.

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